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Patentanmeldung Nr. Patent application No. Demande de brevet n°

00309030.5

Der Präsident des Europäischen Patentamts;
Im Auftrag

For the President of the European Patent Office

Le Président de l'Office européen des brevets
p.o.

R C van Dijk

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Bezeichnung der Erfindung/Title of the invention/Titre de l'invention:
(Falls die Bezeichnung der Erfindung nicht angegeben ist, siehe Beschreibung.
If no title is shown please refer to the description.
Si aucun titre n'est indiqué se referer à la description.)

Camera

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CAMERA

This invention relates to a camera employing a charged coupled device (CCD). Many such cameras are available, however very few are sensitive to particular wavelengths. For example, there is a need to provide a camera for use in the design and manufacture of optical communications high wavelength infra-red systems, but very few cameras which are sensitive to the wavelengths at which such systems work are presently available. The cameras that are available are usually bulky and expensive, making their application in many environments at best impractical, and at worst impossible.

Accordingly, there is a need to provide a camera that is inexpensive and small, yet which is sensitive to particular infrared wavelength ranges.

According to the present invention there is provided a camera comprising:

a charge-coupled device (CCD), the CCD having an anti-stokes phosphor bound to the light receiving surface thereof; and

a housing surrounding the CCD and defining an aperture through which, in use, light can pass and be received by the phosphor CCD.

The term "anti-stokes" refers to an emission process which does not conform to Stoke's second law that a materials' fluorescence emission is lower in photon energy than the absorbed photon energy. Many instances of such effects have been observed in many material systems but perhaps the most efficient of these are from pairs of non-identical triply ionised rare earth ions, e.g. Er^{3+}, Yb^{3+} doped into a crystalline host.

The anti-stokes phosphor may be sensitive to light in the wavelength range of 1500 to 1610nm and preferably emits in the range of 950nm to 1075nm. Anti-stokes phosphors of this type have high efficiency, and can be married to

relatively inexpensive CCD's which are sensitive to the aforementioned emitting wavelength range.

The camera may comprise one or more filters positioned between the aperture and the phosphor coating on the CCD in order to reject ambient light to which the CCD is normally sensitive.

The phosphor may be Y_2O_2S:Er,Yb, YF_3:Er,Yb, $NaYF_4$:Er,Yb, or La_2O_2S:Er,Yb or a related up conversion matrix for example.

The phosphor may be bound to the CCD by an adhesive such as an isobutyl/butyl acrylic copolymer.

One example of the present invention will now be described with reference to the accompanying drawings, in which:

Figure 1 is a schematic diagram of a camera according to the present invention;

Figure 2 is a schematic side view of a charge-coupled device (CCD) employed in the camera of figure 1; and

Figure 3 is a graph showing the spectral response of an example camera according to the present invention.

Figure 1 shows a schematic view of a camera 1 according to the present invention. The camera 1 has a housing 2 which contains a charge coupled device (CCD) 3 having a phosphor coating 4 attached thereto by a binder 5 (see figure 2). The camera housing 2 has an aperture 6 which receives light from an object to be viewed (not shown) and which then passes through one or more filters 7, 8 which filter out unwanted incident light before it reaches the phosphor 4.

In this example the phosphor is Y_2O_2S:ErYb and is particulate, having a particle size range in the range of 5 μm to 9 μm and a density of 4.1 g/cm^3. This is an anti-stokes phosphor which has emission peaks which are excitation dependent, but which can either be in the visible range or at approximately 985nm. The latter peak is a more dominant photon process which is of significantly higher efficiency whilst still maintaining a fast enough

response time to complement that of the camera and provide a lag free image.

Figure 3 is a graph showing the spectral response from the example camera of figures 1 and 2 using a system with a resolution of 4nm. This is based upon the provision of a CCD sensitive to emissions from the phosphor in the range of 950nm to 1075nm. It can be seen that, whilst there is not flat spectral response in the operating range of the camera, this is not important for imaging purposes. The level of detection is influenced by the non-linear response of the phosphor with respect to incident illumination. However, this response of the phosphor with respect to incident illumination has the benefit of emphasising brighter regions of the image. The sensitivity of the camera can be as low as 2 $\mu J/cm^2$. The phosphor camera cannot be readily used as a measure of incident power or as a discriminator between adjacent laser wavelengths due to the non-uniform spectral response. The camera therefore can provide a good level of light detection in the general range of 1500 nm to 1610 nm, the operating range of many telecommunications devices such as optical fibre and free space optical communication networks as well as medical and biological imaging applications.

CLAIMS

1. A camera comprising:

a charge-coupled device (CCD), the CCD having an anti-stokes phosphor bound to the light receiving surface thereof; and

a housing surrounding the CCD and defining an aperture through which, in use, light can pass and be received by the phosphor CCD.

2. A camera according to claim 1, wherein the anti-stokes phosphor is sensitive to light in the wavelength range of 1500 to 1610nm.

3. A camera according to claim 1 or 2, wherein the phosphor preferably emits in the range of 950nm to 1075nm.

4. A camera according to any of claims 1 to 3, further comprising one or more filters positioned between the aperture and the phosphor coating on the CCD.

5. A camera according to any preceding claim, wherein the phosphor is Er,Yb in a host phosphor matrix.

6. A camera according to claim 5, wherein the host phosphor matrix is selected from one of Y_2O_2S, YF_3, $NaYF_4$ and La_2O_2S.

7. A camera according to any preceding claim wherein the phosphor is bound to the CCD by an adhesive.

ABSTRACT

A camera comprises a charge-coupled device (CCD). The CCD has an anti-stokes phosphor bound to the light receiving surface thereof. A housing surrounds the CCD and defines a filtered aperture through which, in use, light can pass and be received by the phosphor CCD.

Figure 1

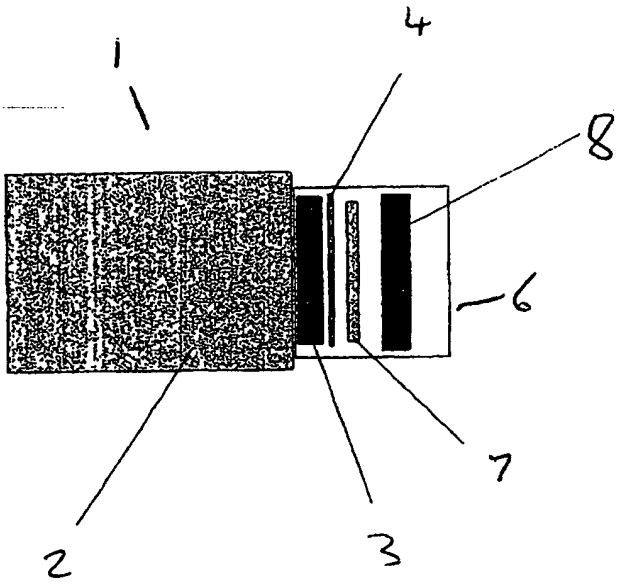


Fig. 2

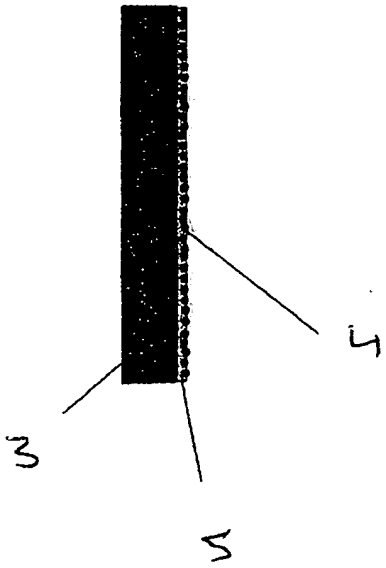
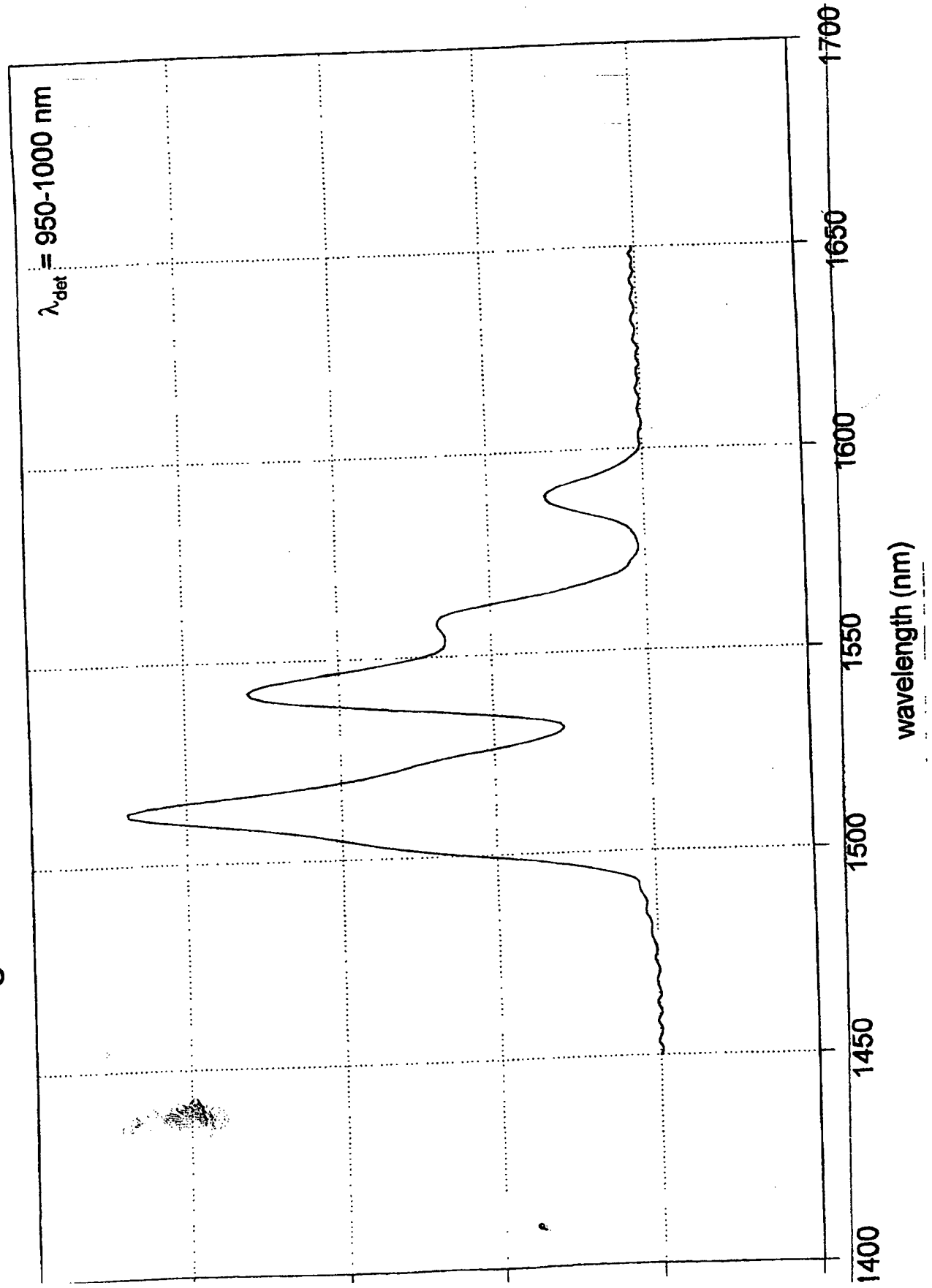


Figure 3


λ_{det} = 950-1000 nm
1400
1450
1500
1550
1600
1650
1700
wavelength (nm)